(12) UK Patent Application (19) GB (11) 2 144 814 A

(43) Application published 13 Mar 1985

(21) Application No 8417492

(22) Date of filing 9 Jul 1984

(30) Priority data
(31) 58/144985 (32) 10 Aug 1983 (33) JP

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(51) INT CL^4
F16H 37/02

(52) Domestic classification
F2D 10B1 10F3 10G2 10G4 10G6 10H4 10K 9C1 9D2 9D4 9D7
U1S 1820 F2D

(56) Documents cited
GB A 2058250 GB 1109950 EP A 0064678
GB 1575381

(58) Field of search
F2D

(54) Driving device including continuously variable transmission

(57) A driving device for a vehicle includes a fluid coupling 12 and an expanding-pulley continuously variable transmission (CVT) 1 connected in series thereto. The driving device further includes a planetary gear mechanism 42 having two forward speeds and connected in series to the CVT. The planetary gear may be of the Ravigneaux or Simpson type and incorporate reverse ratio. It may be positioned downstream of the CVT instead of as shown.

FIG. 1

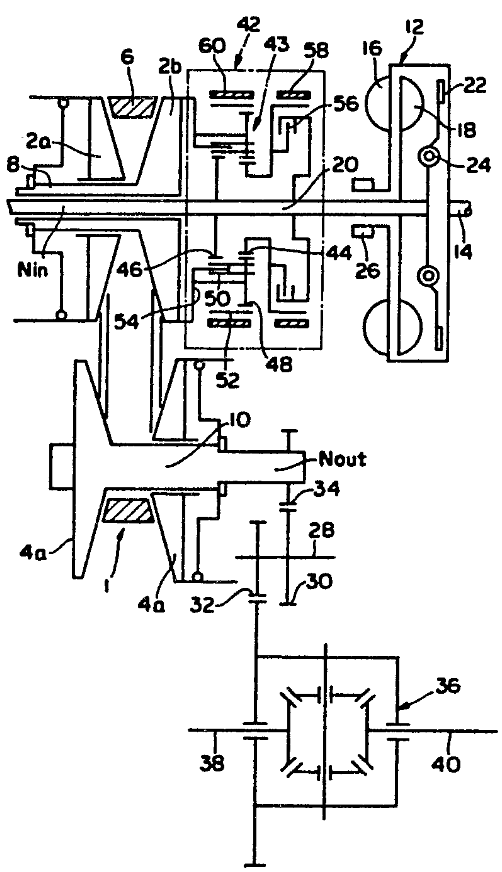

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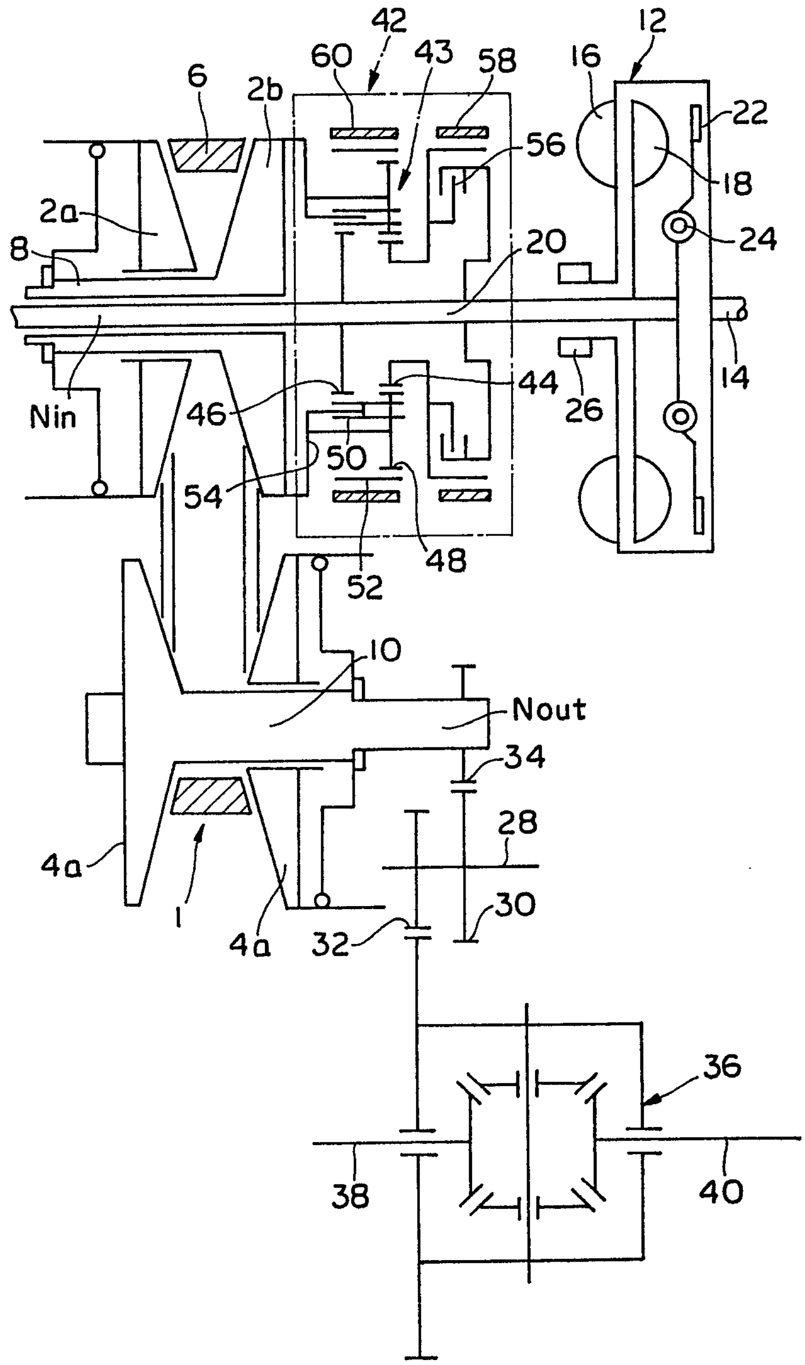
FIG. 1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6
2b
16
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22
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2a
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24
8
20
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Nin
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Nout
34
28
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4a
32
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38
40

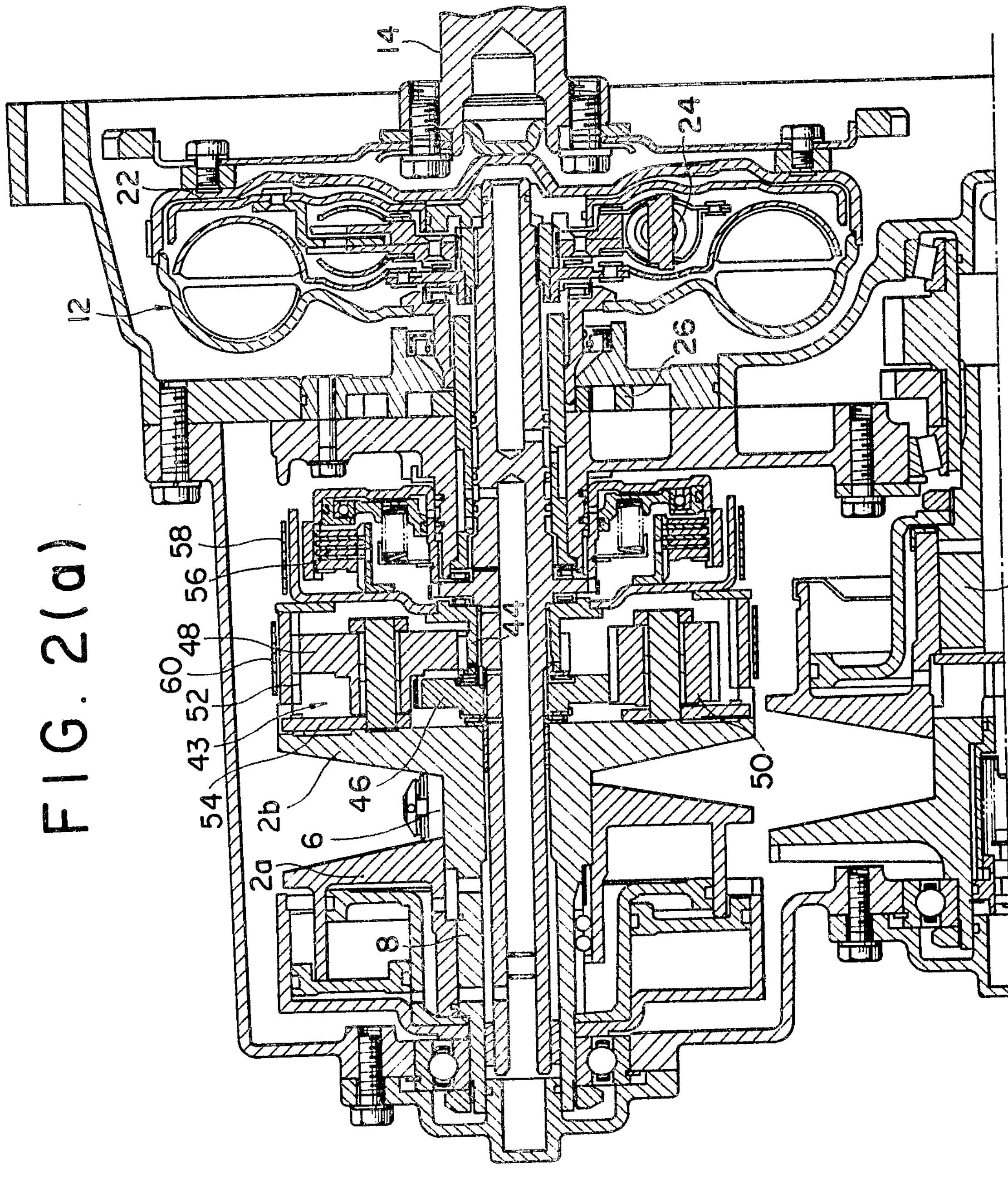

FIG. 2(a)

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FIG. 2(b)

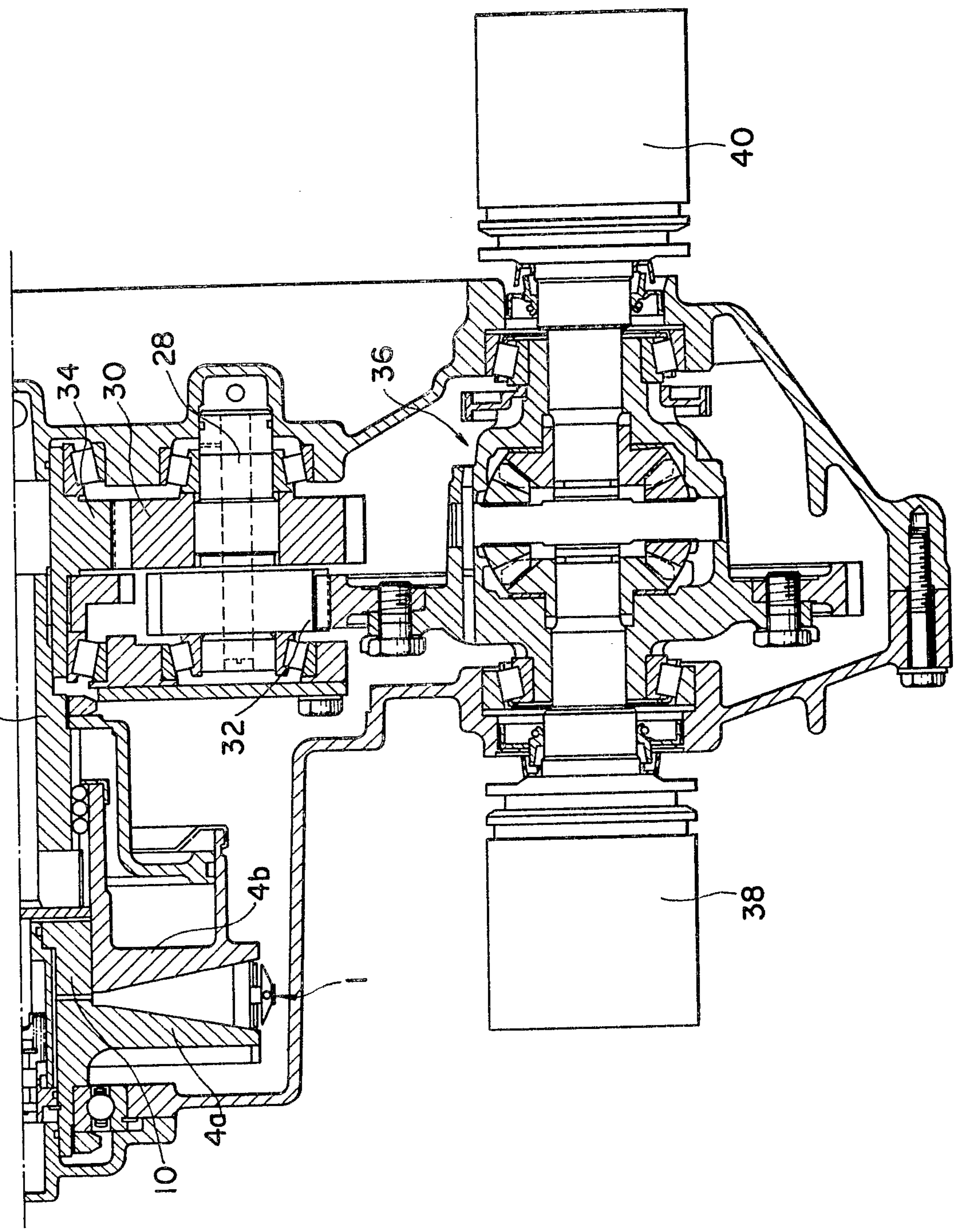


FIG. 3

SHIFT RANGE	CLUTCH 56 FOR HIGH SPEED STAGE	BRAKE 58 FOR LOW SPEED STAGE	BACKWARD BRAKE 60	REDUCTION GEAR RATIO OF PLANETARY GEAR MECHANISM
L (LOW)	X	O	X	$1+\frac{\rho 1}{\rho 2}$
D (DRIVE)	O	X	X	1
N (NEUTRAL)	X	X	X	—
R (REVERSE)	X	X	O	$-(1-\frac{1}{\rho 2})$

FIG. 4

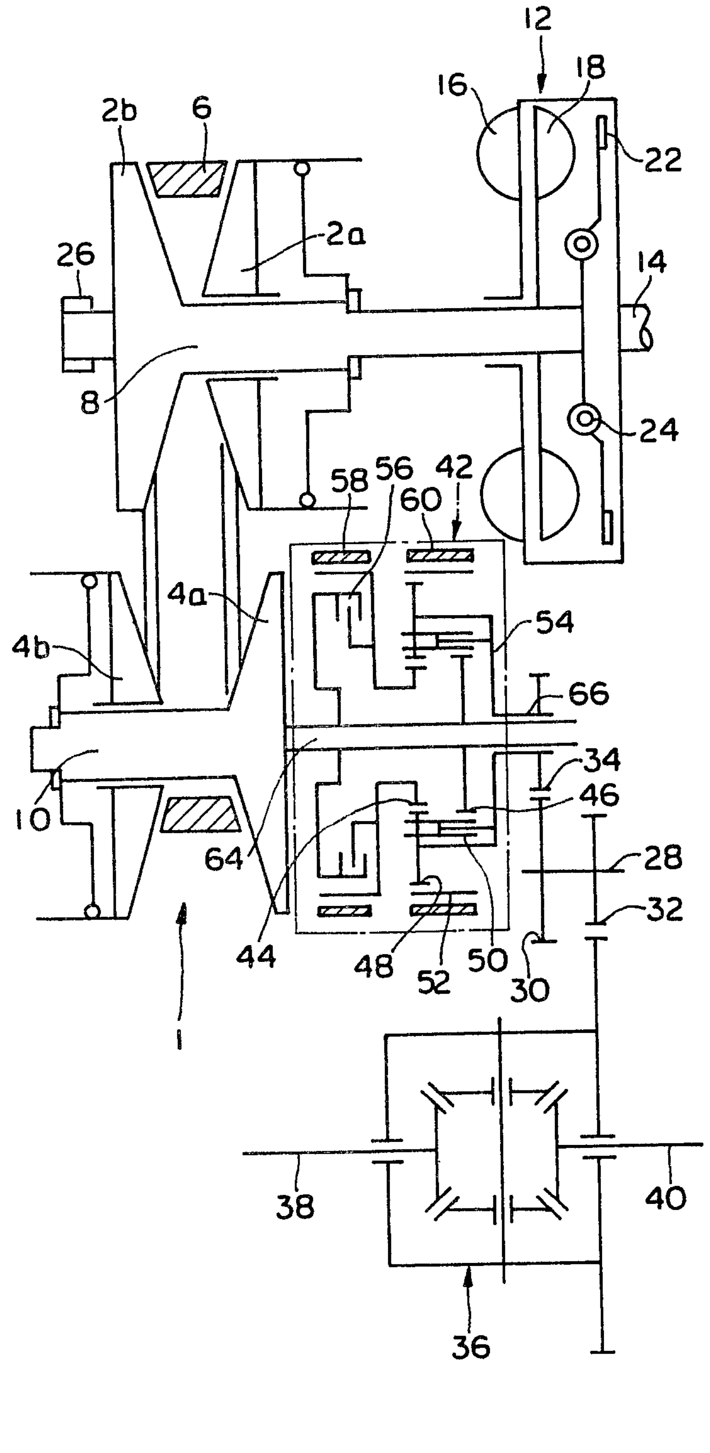
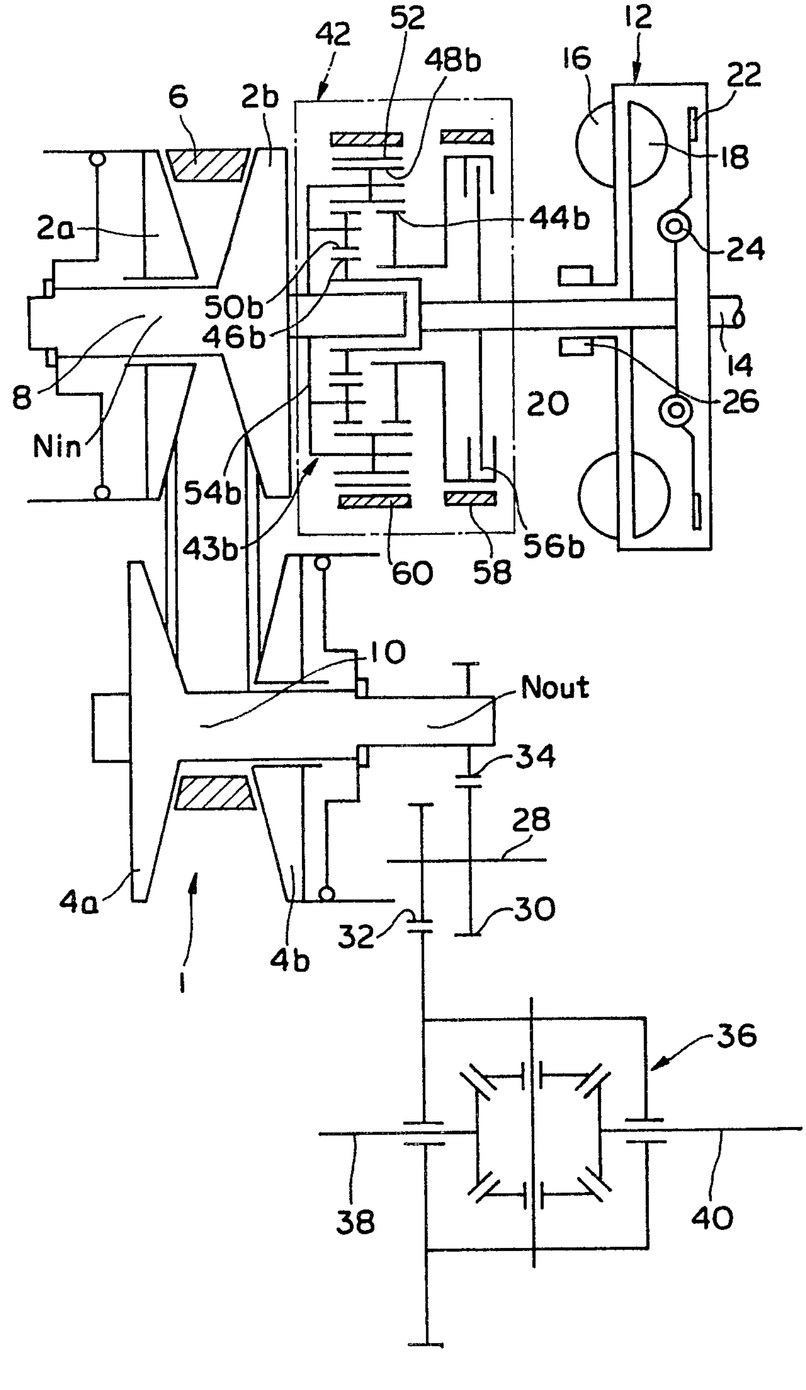

12
16
18
2b
6
22
2a
26
14
8
24
58
56
42
60
4a
54
4b
66
34
10
46
28
64
32
44
48
52
50
30
1
38
40
36

FIG. 5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42
48b
12
16
22
6
2b
18
2a
44b
24
50b
46b
14
8
26
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Nin
54b
43b
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58
10
Nout
34
28
4a
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32
4b
1
36
38
40

FIG. 6

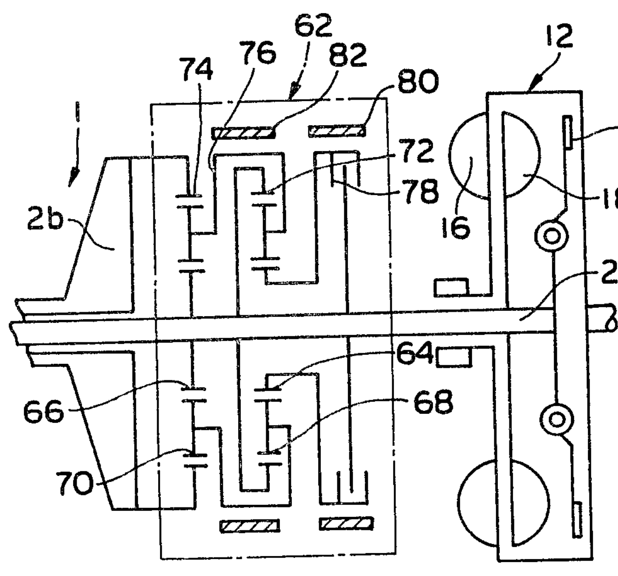

FIG. 7

SHIFT RANGE	CLUTCH 78 FOR HIGH SPEED STAGE	BRAKE 80 FOR LOW SPEED STAGE	BACKWARD BRAKE 82	REDUCTION GEAR RATIO OF PLANETARY GEAR MECHANISM
L (LOW)	X	○	X	$\frac{1+\gamma 1}{1-\gamma 1 \cdot \gamma 2}$
D (DRIVE)	○	X	X	1
N (NEUTRAL)	X	X	X	—
R (REVERSE)	X	X	○	$-\frac{1}{\gamma 2}$

SPECIFICATION

Driving device including continuously variable transmission

The present invention relates to a driving device including a continuously variable transmission (hereinafter called "CVT").

A CVT capable of controlling continuously speed ratio e (= output side rotational speed Nout/input side rotational speed Nin) is used for a vehicle as a power transmission with excellent specific fuel consumption. In consideration of the power performance of the CVT in start of hill-climbing, the maximum reduction gear ratio (reduction gear ratio = 1/e) needs to have a large value, and considering the specific fuel consumption, it is advantageous to set the reduction gear ratio to a small value since the thermal efficiency of general internal combustion engine is high in low engine speed and high torque. Thus, to reconcile both power performance and specific fuel consumption to each other, the range of controlling the change gear ratio, i.e. change gear width in the CVT needs to be increased. To increase the change gear width, however, the distance between the input and output shafts of the CVT needs to be increased while increasing the diameter of a pulley, or belt wound diameter needs to be reduced. In the former case, the CVT becomes disadvantageously large-sized and increases its weight, and in the latter case the durability of the belt is disadvantageously degraded. Thus, the change gear width in prior continuously variable transmission is extremely limited so that it was difficult to reconcile both the power performance in unusual case such as start in high climbing along steep gradient slope and the specific fule consumption in usual case.

An object of the present invention is to provide a driving device including a continuously variable transmission which is to optimize both power performance in unusual case and specific fuel consumption in usual case.

In the driving device including the continuously variable transmission according to the present invention to achieve this object, a forward 2-stage planetary gear mechanism is provided in series to a belt system CVT in an engine power transmitting passage including a fluid-type transmission connected to the output shaft of the engine in the input side and the belt system CVT having an input side pulley arranged coaxially with the fluid-type transmission and an output side pulley having the axis parallel to the axis of the input side pulley.

Thus, the planetary gear mechanism is to compensate for the change gear width which is insufficient in the CVT alone and increase the change gear width of the whole transmission gear.

The high speed and low speed stages of the planetary gear mechanism are set respectively for running in usual case and increasing reduction gear ratio in unusual case for example.

Thus, in the usual case, the planetary gear mechanism is held at the high speed stage and thereby the whole reduction gear ratio of the continuously variable transmission is held at a small value so that the specific fuel consumption in usual running is to be improved. Also, the planetary gear mechanism is held at the low speed stage in the unusual case such as start on a steep gradient slope, climbing and decending a steep gradient slope and thereby the whole reduction gear ratio of the continuously variable transmission is held at a large value so that a large drive force and engine brake in the unusual running case are to be ensured. Also, since sufficient power performance and specific fuel consumption are ensured even if the change gear width of the CVT is reduced by the addition of the planetary gear mechanism, so that the CVT itself is to be made compact and light while improving its durability.

Further, a change between the high and low speed stages in the planetary gear mechanism is effected by the manual operation of a shift lever or electric switch in a driver's sheet or by the automatic operation signals caused by an electronic control unit. Alternatively, the high and low speed stages may be automatically changed over in the low range by utilizing the same principle as that of a well-known change gear valve controlled by governor pressure and throttle pressure in a hydraulic control unit for an automatic transmission.

The fluid-type transmission may be a fluid-type torque converter or a fluid coupling.

In a preferred embodiment of the present invention, the planetary gear mechanism is provided upstream or downstream of the CVT in the power transmission passage of the engine. When the planetary gear mechanism is provided upstream of the CVT, the input torque of the planetary gear mechanism is small at the level of the engine torque so that the planetary gear mechanism is to be made compact. When the planetary gear mechanism is provided downstream of the CVT, the input torque of the CVT is small at the level of the engine torque so that the durability of the CVT is advantageously improved.

In the preferred embodiment of the present invention, the planetary gear mechanism includes a Ravigneaux type complex planetary gear unit which is provided with first and second sun gears, a first planetary gear meshing with the first sun gear, a second planetary gear meshing with the second sun gear and the first planetary gear, a ring gear meshing with the first planetary gear and a carrier for supporting rotatably the first and second planetary gears. The first sun gear is connected to the input portion of the planetary gear mecha-

nism through a clutch for the high speed stage, the second sun gear connected directly to the input portion of the planetary gear mechanism, the carrier connected to the output portion of the planetary gear mechanism and a brake for the low speed stage to control the fixation of the ring gear is provided.

In another preferred embodiment of the present invention, the planetary gear mechanism includes a Simpson type combined planetary gear unit which is provided with first and second sun gears, first and second planetary gears meshing respectively with the first and second sun gears, first and second ring gears meshing respectively with the first and second planetary gears and a carrier for supporting rotatably the first and second planetary gears. The first sun gear is connected to the input portion of the planetary gear mechanism through a clutch for the high speed stage, the first ring gear and the second sun gear are connected directly to the input portion of the planetary gear mechanism, the second ring gear constitutes the output portion of the planetary gear mechanism and a brake for the low speed stage to fix the first sun gear is provided.

Further objects, features and advantages of the present invention will become readily apparent from the consideration of the following description, the appended claims and accompanying drawings, in which:–

Figure 1 is a skeleton view showing an embodiment of the present invention;

Figures 2(a) and (b) are detailed views showing an embodiment according to the skeleton view in Fig. 1;

Figure 3 is a table showing the operational conditions of respective frictionally engaging units in respective shift ranges in the embodiment of Fig. 1;

Figures 4, 5 and 6 are skeleton views of other embodiments of the present invention respectively; and

Figure 7 is a table showing the operational conditions of the respective frictionally engaging units in respective shift ranges in the embodiment of Fig. 6.

Figs. 1 and 2 are repsectively skeleton and detailed views of a first embodiment of the present invention in which a CVT 1 is provided with a pair of input side pulleys 2a, 2b, a pair of output side pulleys 4a, 4b and a belt 6 trained over the output side pulleys 4a, 4b and pulleys at the input and output sides to transmit an engine power. One input side pulley 2a is mounted on a shaft 8 of the other input side pulley 2b to be moved axially and fixed rotationally, and the shaft 8 is supported rotatably by a housing. Also, one output side pulley 4a is secured fixedly to an output shaft 10 and the other output side pulley 4b is mounted on the output shaft 10 to be moved axially and fixed rotationally. The opposed surfaces of the input side pulleys 2a, 2b and the opposed surfaces of the output side pulleys 4a, 4b are formed tapered such that the distance between them is increased radially outward, and the cross section of the belt 6 is shaped into an equilateral trapezoidal one. The press force of the output side pulleys 4a, 4b is controlled to the minimum value to avoid the slip of the belt 6 and ensure the power transmission, and the press force of the input side pulleys 2a, 2b determines the speed ratio e (= rotational speed Nout of output side pulleys 4a, 4b/rotational speed Nin of input side pulleys 2a, 2b) of the CVT 1. A fluid coupling 12 is provided with a pump 16 connected to a crankshaft 14 of an engine, a turbine 18 rotated by oil from the pump 16 and an output shaft 20 connected to the turbine 18. A direct clutch 22 controls the connection between the crankshaft 14 and the output shaft 20, and a damper 24 absorbs shock and torque variation of the engine when the direct clutch is changed over from the released condition to the engaged condition. When vehicle speed or engine speed exceeds a predetermined value, the direct clutch 22 is held at the engaging condition to avoid the loss of power transmission given by oil in the fluid coupling. An oil pump 26 is rotated integrally with the pump 16 to send oil to the CVT 1, the fluid coupling 12, etc. through a hydraulic control unit not shown. A counter shaft 28 is provided parallel to the output shaft 10 of the CVT 1 and has two gears 30, 32. The engine power of the output shaft 10 is transmitted from a gear 34 on the output shaft 10 to a differential unit 36 through the gears 30, 32 on the counter shaft 28 and further sent to left and right drive wheels from the differential unit 36 through left and right axle shafts 38, 40. A planetary gear mechanism 42 is provided coaxially with and betwen the crankshaft 14 and the input side pulleys 2a, 2b of the CVT 1. The planetary gear mechanism 42 includes a Ravigneaux type complex planetary gear unit 43 which is provided with first and second sun gears 44, 46, a first planetary gear 48 meshing with the first sun gear 44, a second planetary gear 50 meshing with the first planetary gear 48 and the second sun gear 46, a ring gear 52 meshing with the first planetary gear 48 and a carrier 54 for supporting rotatably the first and second planetary gears 48, 50. The second sun gear 46 is connected to the output shaft 20 as an input portion of the planetary gear mechanism 42, and the carrier 54 connected to the input side pulley 2b of the CVT 1. A clutch 56 for the high speed stage controls the connection between the output shaft 20 and the first sun gear 44, a brake 58 for the low speed stage controls the fixation of the first sun gear 44 and a backward brake 60 controls the fixation of the ring gear 52. In this embodiment since the input of the planetary gear mechanism 42

is at the level of the engine torque, the planetary gear mechanism is to be made compact and light.

Fig. 3 shows the operational conditions of respective frictionally engaging elements and the reduction gear ratio in the respective ranges of the planetary gear mechanism 42. Mark O means the engaging condition and mark X means the released condition. The P1 and P2 are defined from the following equation;

$P1 = Zs1/Zr$

$P2 = Zs2/Zr$

where Zs1 is the number of teeth of the first sun gear 44, Zs2 is the number of teeth of the second sun gear 46 and Zr is the number of teeth of the ring gear 52. Namely, since the first sun gear 44 is fixed by the brake 58 for the low speed stage in L range, the engine power is transmitted at the reduction gear ratio of $1 + P1/P2$. The clutch 56 for the high speed stage is set to the engaged condition in D range and the planetary gear unit 43 is rotated integrally, so that the engine power is transmitted at the reduction gear ratio 1. Since the ring gear 52 is fixed by a backward brake 60 in R range, the engine power is transmitted at the reverse rotation of the reduction gear ratio of $1-1/P2$. In a large payload and start on a steep gradient slope or in a unusal case such as climbing on a steep gradient slope, the L range is selected to obtain a large drive force and engine brake. In an usual time such as start on a gentle gradient, the D range is selected and the whole reduction gear ratio of the continuously variable transmission is determined only by the speed ratio of the CVT 1.

Fig. 4 shows another embodiment of the present invention, in which only points differing from the embodiment in Fig. 1 will be described.

The planetary gear mechanism 42 is provided coaxially with the output shaft 10 of the CVT 1 and downstream of the CVT 1. Thus, the fluid coupling 12 is connected directly to the shaft 8 of the CVT 1, an input shaft 64 of the planetary gear mechanism 42 is connected to the output shaft 10 of the CVT 1 and the gear 34 meshing with the gear 30 of the counter shaft 28 is secured fixedly to an output shaft 66 of the planetary gear mechanism 42. In this embodiment, since the input torque of the CVT 1 is at the level of the engine torque, advantageous durability of the CVT 1 is provided.

Fig. 5 shows a modification of the embodiment shown in Fig. 1. Namely, the planetary gear mechanism 42 is provided with a further Ravigneaux type complex planetary gear unit 43b in which a second planetary gear 50b meshes with a first planetary gear 48b from radially inner side, a carrier 54b is connected to the input shaft 8 of the CVT 1 and further a clutch 56b for the high speed stage is connected to the output shaft 20, not at the drum side, but at the disk side.

Fig. 6 shows another embodiment of the present invention in which the planetary gear mechanism 42 includes the Simpson type combined planetary gear unit 62. This planetary gear unit 62 is provided with first and second sun gears 64, 66, first and second planetary gears 68, 70 meshing with the first and second sun gears 64, 66, first and second ring gears 72, 74 meshing with the first and second planetary gears 68, 70 and a carrier 76 for supporting rotatably the first and second planetary gears 68, 70. The first ring gear 72 and the second sun gear 66 are connected to the output shaft 20 of the fluid coupling 12 and the second ring gear 74 is connected to the input side pulley 2b. A clutch 78 for the high speed stage controls the connection between the first sun gear 64 and the output shaft 20 of the fluid coupling 12, a brake 80 for the low speed stage controls the fixation of the first sun gear 64 and a backward brake 82 controls the fixation of the carrier 76. The operation and the reduction gear ratio of respective frictionally engaging units in respective shift ranges are shown in Fig. 7, where marks O and X mean respectively the engaging condition and released condition, $\gamma1$ = number of teeth of first sun gear 64/number of teeth of first ring gear 78 and $\gamma2$ = number of teeth of second sun gear 66/number of teeth of second ring gear 74.

While it will be apparent that the embodiments of the present invention herein disclosed are well calculated to fulfill the objects of the present invention, it will be appreciated that the present invention is susceptible to modification, variation and change without departing from the proper scope of fair meaning of the subjoined claims.

CLAIMS

1. A driving device including a continuously variable transmission comprising:

a fluid-type transmission connected to an output shaft of the engine at the input side;

an engine power transmitting passage including the belt system continuously variable transmission having an input side pulley arranged coaxially with the fluid-type transmission and output side pulley having the axis parallel to the axis of the input side pulley; and

a forward 2-stage planetary gear mechanism provided in series to a belt system continuously variable transmission.

2. A driving device including a continuously variable transmission as defined in claim 1, wherein the low speed stage of the planetary gear mechanism is set for increasing the reduction gear ratio.

3. A driving device including a continuously variable transmission as defined in claim

2, wherein the fluid-type transmission is a fluid coupling or a fluid-type torque converter.

4. A driving device including a continuously variable transmission as defined in claim 1, wherein the planetary gear mechanism is provided upstream of the belt system continuously variable transmission in the engine power transmitting passage.

5. A driving device including a continuously variable transmission as defined in claim 1, wherein the planetary gear mechanism is provided downstream of the belt system continuously variable transmission in the engine power transmitting passage.

6. A driving device including a continuously variable transmission as defined in claim 1, wherein the planetary gear mechanism includes a Ravigneaux type complex planetary gear unit.

7. A driving device including a continuously variable transmission as defined in claim 6, wherein the Ravigneaux type complex planetary gear unit is provided with first and second sun gears, a first planetary gear meshing with the first sun gear, a second planetary gear meshing with the second sun gear and the first planetary gear, a ring gear meshing with the first planetary gear and a carrier for supporting rotatably the first and second planetary gears, the first sun gear being connected to the input portion of the planetary gear mechanism through a clutch for the high speed stage, the second sun gear being connected directly to the input portion of the planetary gear mechanism, the carrier being connected to the output portion of the planetary gear mechanism and the brake for the low speed stage being provided for controlling the fixation of the ring gear.

8. A driving device including a continuously variable transmission as defined in claim 1, wherein the planetary gear mechanism includes a Simpson type combined planetary gear unit.

9. A driving device including a continuously variable transmission as defined in claim 8, wherein the Simpson type combined planetary gear unit is provided with first and second sun gears, first and second planetary gears meshing with the first and second sun gears respectively, first and second ring gears respectively meshing with the first and second planetary gears and a carrier for supporting rotatably the first and second planetary gears, the first sun gear being connected to the input portion of the planetary gear mechanism through the clutch for the high speed stage, the first ring gear and the second sun gear being connected directly to the input portion of the planetary gear mechanism, the second ring gear constituting the output portion of the planetary gear mechanism and the brake for the low speed stage being provided for fixing the first sun gear.

10. A driving device including a continuously variable transmission as defined in Claim 7 or 9, wherein the low speed stage of the planetary gear mechanism is set for increasing the reduction gear ratio.

11. A driving device including continuously variable transmission, substantially as hereinbefore described with reference to, and as shown in, Figs. 1 and 2 or Fig. 4, or Fig. 5, or Fig. 6 of the accompanying drawings.

12. A vehicle having a driving device as claimed in any preceding Claim.

Printed in the United Kingdom for
Her Majesty's Stationery Office. Dd 8818935. 1985. 4235
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained

PUB-NO: GB002144814A

DOCUMENT-IDENTIFIER: GB 2144814 A

TITLE: Driving device including continuously variable transmission

PUBN-DATE: March 13, 1985

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APPL-NO: GB08417492

APPL-DATE: July 9, 1984

PRIORITY-DATA: JP14498583A (August 10, 1983)

INT-CL (IPC): F16H037/02

EUR-CL (EPC): F16H037/02 , F16H047/06

US-CL-CURRENT: 74/12 , 475/210

ABSTRACT:

CHG DATE=19990617 STATUS=O> A driving device for a vehicle includes a fluid coupling 12 and an expanding-pulley continuously variable transmission (CVT) 1 connected in series thereto. The driving device further includes a planetary gear mechanism 42 having two forward speeds and connected in series to the CVT. The planetary gear may be of the Ravigneaux or Simpson type and incorporate reverse ratio. It may be positioned downstream of the CVT instead of as shown.